Two surveys of scientists and others associated with animal research "suggest that most animal researchers favor [Animal Welfare Act] regulation of mice, rats, and birds." Various ideas are offered about what might have caused the gully-like features recently found on Mars. The author of the 1973 book *Stability and Complexity in Model Ecosystems* clarifies a major point of his book that has been misinterpreted. And imagine beating Muhammed Ali in his prime in the boxing ring—the probability of that happening (and there is one) illustrates the role of "outrageous events" in calculating statistical significance.

Poll Shows Researchers Favor Lab Animal Protection

In the News of the Week article "Researchers fight plan to regulate mice, birds" (6 Oct., p. 23), David Malakoff portrays animal researchers as being "furious" with a decision by the U.S. Department of Agriculture to add mice, rats, and birds to the list of animals protected under the Animal Welfare Act (AWA). As seen in the accompanying table, however, a recent survey of Institutional Animal Care and Use Committee (IACUC) members reveals that most researchers actually favor AWA regulation of these species.

PERCENTAGE OF IACUC MEMBERS FAVORING AWA REGULATION OF SPECIFIC ANIMALS

	IACUC members	
Type of animal	Animal researchers (*N* = 287)	Other members (*N* =199)
Primates	99.7	98.0
Dogs	98.6	96.5
Cats	98.3	96.5
Rats/mice	73.9	71.9
Pigeons	67.9	69.8

These data come from a survey we conducted of 565 members drawn from a random sample of 50 college and university IACUCs (*1*). IACUC members represent individuals with extensive experience implementing AWA regulations. Our respondents averaged 5.3 years of IACUC service, and more than 90% reported reviewing animal research protocols on a regular basis. Of the questionnaires sent out, we received 494 responses (an 87% return rate), including 486 responses to the following question: "The Animal Welfare Act is a federal law that governs the use of animals in research. Regardless of the species now covered under the Animal Welfare Act, which of the following animals should, in *your* opinion, receive AWA protection when used for research?"

A clear majority of animal researchers and other IACUC members favored AWA coverage for mice, rats, and birds. Even animal researchers in psychology, psychopharmacology, and behavioral neuroscience support AWA coverage of these animals, despite the fact that these disciplines would be among the most affected by AWA regulation of mice, rats, and birds. Of 158 self-identified animal researchers who responded to a 1994 national survey of psychologists, 73% favored AWA coverage for rats and mice and 72% favored coverage for pigeons (*1*, *2*). Taken together, these results suggest that most animal researchers favor AWA regulation of mice, rats, and birds.

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Ideas About the Surface Runoff Features on Mars

In their report "Evidence of recent groundwater seepage and surface runoff on Mars" (30 June, p. 2330), Malin and Edgett propose that the seepage and flow of water may have occurred on Mars in the recent geologic past, on the basis of the observation of a large number of channel features on steep, poleward-facing slopes in the southern hemisphere. They acknowledge that this observation would be strongly contrary to other observational evidence that Mars is extremely dry and the regolith desiccated to considerable depth. Instead, another possibility is that we are seeing the consequences of volatile activity related to CO_2 permafrost and gas-supported grain flows. The regions of Mars where these features have been found are those where solid CO_2 is stable in the near-surface. Earth analogs for this class of flow would be the collapse of viscous lava domes from andesitic volcanoes such as Unzen (in Japan) and Soufriere (in West Indies), where the generation of fluidized clouds of rock and ash supported by volcanic gases are well documented. The morphology of these pyroclastic flows is essentially identical to that presented by Malin and Edgett. An arcuate alcove or amphitheater scar leads through ravined chutes to a leveed flow channel down the side of the volcano. The flow pattern, which may be braided as in the Mars examples, leads to a depositional fan with lobate geometry. Surprisingly large boulders can be transported in these gas-supported flows.

I emphasize that I am not invoking a volcanic origin for these flow features on Mars. Instead, I suggest that subsurface cryogenic liquid CO_2 and solid CO_2 permafrost become involved in small-scale collapse events in these steep terrains. As Tanaka points out in his Perspective "Fountains of youth" (*Science*'s Compass, June 30, p. 2325), explosive expansion of CO_2 when it is decompressed is an ideal mechanism for generating a vapor-lubricated grain flow or a full-scale gas-supported density flow.

Malin and Edgett comment on the lack of older examples of these flows. However, as other authors have shown (*1*, *2*), the martian outburst "flood" channels are themselves ideally explained by just such a mechanism working on a larger scale at a time when planetary warming of near-equatorial regions warmed thick CO_2 permafrost. The evidence for water on Mars, either recent or past, remains to be demonstrated.

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We suggest that dense, eutectic, valley-forming, intermediate-latitude (DEVIL) brine is the likely fluid that flowed out of escarpments at subfreezing temperatures on Mars as reported by Malin and Edgett. Any early ocean on Mars is likely to have had high initial salinity (*1*). Subsequent large-scale escape of water would have left behind dense brines that sank into the shallow subsurface and evolved chemically by reaction with basaltic rubble. Upon subsequent climatic freezing, crystalliza-

tion of hydrous Na-Ca-Mg-chloride salts results in progressively more concentrated brine and progressively lower freezing temperatures. Many multicomponent eutectic brines have very low freezing temperatures (*2*) and could therefore still be present in the shallow martian subsurface as remnants of an early ocean.

Appropriate experimental data are absent, so we examined the freezing points of several naturally occurring terrestrial brine samples at –64°C in a simulated martian atmosphere (6 millbars CO_2). Residual liquid remained in brine that had an initial concentration of Mg of 18.2 grams/liter and of Ca of 98 grams/liter (*3*). Even more concentrated brines occur on Earth. Brines of Cl were previously dismissed because they are chemically inconsistent with sulfate salts presumed to occur in the martian regolith (*4*). In our scenario, brines descended into horizons of higher porosity or permeability long before modern regolith formation.

At high latitudes, temperatures are low enough to freeze the brines. At lower latitudes, temperatures should become warm enough to evaporate them as they seep toward the surface. This could explain the puzzling restriction of the outflow channels to intermediate latitudes.

Gravity-driven outflows of shallow, dense (specific gravity >1.3) eutectic fluids remain near thermal equilibrium with their environment, so further precipitation of dissolved constituents is unlikely. The fluid would simply sink into the ground with no visible deposit at the outflow terminus, as could be the case on Mars.

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Malin and Edgett present images that provide compelling geomorphic evidence for surface runoff of martian groundwater in the recent geologic past. As reported, the runoff features have been observed poleward of 30° latitude, predominantly on poleward-facing slopes; the features are absent in the tropics and on sunward-facing slopes (that is, places of maximum in-

solation) at higher latitudes. We suggest that this distribution is a map of ground ice distribution and is what would be expected if the source of the surface runoff is derived from subsurface ice. Near-surface ground ice is predicted to be stable poleward of about 30° (*1*, *2*), although there may be localized exceptions nearer the equator (*3*). At higher latitudes ground ice would tend to retreat from warmer (sun-facing) slopes, reducing the likelihood that surface runoff would occur on those slopes. The mystery that remains is what heat source melts the ice in these regions and sustains it as water long enough that it can produce the observed erosion, transport, and deposition.

The Mars 2001 Orbiter scheduled to launch next April could test the water hypothesis. The Gamma Ray Spectrometer includes a neutron spectrometer to map hydrogen distribution at several-hundred-kilometer resolution that should reflect any global pattern of near-surface ice. The Thermal Emission Imaging Spectrometer with 100-meter resolution may detect evaporite or alteration products associated with runoff, including deposits left behind by brines. Missions being studied or being built for 2003 could provide relevant measurements with higher spatial resolution imaging cameras, visible and near-infrared spectrometers, and atmospheric sounders to search for plumes of water near the surface.

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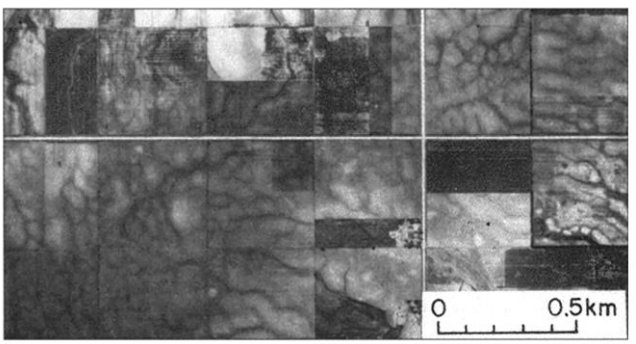
In their report, Malin and Edgett present evidence of modern "spring" deposits on Mars. The significance of this paper depends on the accuracy of the proposed depositional chronology (modern to ~1 million years before the present). The authors' age estimates are mainly based on an absence of craters, with ancillary evidence provided by the spring deposits' superposition on aeolian deposits and patterned ground and by their sharp depositional boundaries.

We find the crater and aeolian evidence compelling, but have reservations regarding the use of patterned ground to establish these deposits as modern. The authors argue that the polygons are formed on short time scales and can only survive for hundreds of thousands of years owing to their fragility. It has yet to be established, however, that any patterned ground on Mars is active. We argue that inactive (fossil) patterned ground is not fragile, as is demonstrated by examples up to 20,000 years old that are still visible in aerial photographs in Scandinavia (*1*) and in plowed fields in Illinois in the United States (*2*) (see the figure). In the Antarctic dry valleys, patterned ground has been documented that has undergone little change in ~15 million years (*3*). We do not see older examples on Earth because fossil patterned ground is typically found in areas that have a history of glaciation (that is, complete resurfacing). On Mars, the low erosion rates and absence of plate tectonics could preserve fossil patterned ground well beyond the 1-million-year time span.

The patterned ground indicates that periglacial processes (those indicative of cold, nonglacial environments) are or have been active on Mars. With this in mind, it is striking that the alcoves reported by Malin and Edgett have a form similar to nivation hollows (from erosion due to frost action or flow of meltwater) or drainage

from near-subsurface icings in polar environments on Earth (*4*). The broad concavities of the alcoves resemble terrestrial features formed by discharge at the base of an "active layer" and subsequent accretion of ice. Further, we propose that the martian discharge is saline or hypersaline. Given the apparent absence of a global water cycle on Mars, any groundwater should have long subsurface residence times (perhaps more than a billion years), resulting in prolonged mineral contact and potentially very high salinity. Hypersaline water is also a common feature of the coldest and driest regions on Earth, such as the Antarctic dry valleys (*5*). Saline groundwater discharge would be more stable than fresh water near the martian surface, resulting in a more fluidized flow. As saline groundwater approached the surface, initial freezing and/or vaporization would occur, depending on the relative rates of temperature and pressure change near the surface. On the surface, water would have a salinity-dependant depression in vapor pressure, allowing some brine to flow downhill and further concentrate with evaporation (which will further depress the vapor pressure). Eventually surface flow would cease, leaving behind a channelized trail of evaporites, and possibly icings in the immediate region of the discharge points. Some flows may have taken place over near-surface icings from previous events, which could explain the discontinuous channels observed. The apparent lack of current ice or evaporitic deposits indicates that the channels may be relict forms.



An aerial view of fossil patterned ground preserved in plowed fields in central Illinois.

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Relation Between Diversity and Stability, in the Real World

Peter Taylor, commenting on a 25 August News Focus article by Jocelyn Kaiser, criticizes her for repeating "the conventional wisdom that Robert May's theoretical work in the 1970s showed that diversity works against stability" (*Science*'s Compass, Letters, 6 Oct., p. 51). Taylor then sets out his own sensible views, which differ from this. Although this may be the interpretation currently attributed to my 1973 book (*1*), it is not what I actually wrote.

In 1973, there was a widely cited belief that more complex or diverse ecosys-